An Analysis Of Mathematics Teacher Candidates' Critical Thinking Dispositions And Their Logical Thinking Skills

Lutfi Incikabi, Kastamonu University, Turkey
Abdulkadir Tuna, Kastamonu University, Turkey
Abdullah Cagri Biber, Kastamonu University, Turkey

ABSTRACT

This study aimed to investigate the existence of the relationship between mathematics teacher candidates' critical thinking skills and their logical thinking dispositions in terms of the variables of grade level in college, high school type, and gender. The current study utilized relational survey model and included a total of 99 mathematics teacher candidates from the department of elementary mathematics education at a university in Turkey. Among the results of the study were that mathematics teacher candidates had a low level of logical thinking skills and critical thinking dispositions; mathematics teacher candidates' logical thinking skills were improved from second grade to third grade level while their critical thinking skills did not change considerably by the grade level; mathematics teacher candidates' critical thinking abilities did not affect considerably by the high school type that were graduated from while regular high school graduates possessed lower level of logical thinking abilities than the others; a weak and negatively directed correlation between mathematics teacher candidates' critical thinking dispositions and their logical thinking skills was evident.

Keywords: Critical Thinking Dispositions; Logical Thinking Skills; Mathematics Teacher Candidates

INTRODUCTION

Critical thinking has been received a considerable amount of interest from scholars. In 1962, Robert Ennis provided the very first definition of the critical thinking as finding the meaning of a statement and to decide whether to accept or reject it (Kazancı, 1989). Another definition of the critical thinking comes from Johnson (2000). According to him, "critical thinking is a demonstration of thought that classifies, analyzes and evaluates an interest. Halpern (1993) provides different aspect of critical thinking as a skill of using cognitive abilities or strategies to increase the achievement rate of intended behaviors. On the other hand, Norris and Ennis (1989) provides a construction of critical thinking on logical thinking by indicating that critical thinking is a decision making process that requires logical and reflective thinking on what to do or what to believe.

Critical thinking does not require disputing or looking for negative critics (Külahçı, 1995). Özden (1997, 1998) explain critical thinking as "critical, evaluative, analytical, attentive, and independent." In addition, Aydin (2000) asserts that critical thinking needs logical thinking to provide meaningful relations among independent variables. Being in line with this assertion, Ministry of National Education (MoNE) in Turkey also states "critical thinking is a process including such mental procedures as reasoning, analysis, and evaluation" (MoNE, 2012), and categorizes logical thinking within the steps of critical thinking.

Piaget defines logical thinking as mental procedures that one utilizes when an unknown situation (problem) occurs (Karplus, 1977). Among Piaget's cognitive stages of development, logical thinking is a skill included in the concrete operational and formal operational stages. In the former, children use logical thinking during problem solving, while in the latter, children achieve the level of adults in terms of logical thinking development (Selçuk,

2001). This development helps individuals to use their cognitive operations to overcome difficulties encountered in their life and also to make generalizations and deductions from these experiences (Korkmaz, 2002). Logical thinking also require the skill of using numbers effectively, producing scientific solutions to the problems, detecting the differences among the concepts, classifying, generalizing, formulating, computing, hypothesizing, testing, and assimilating (Demirel, 2003). Five formal reasoning modes consisting of controlling variables, proportional, probabilistic, correlational, and combinatorial reasoning have been also identified as essential abilities for success in school science and mathematics courses (Bitner, 1991; DeCarcer, Gabel, & Staver, 1978; Lawson, 1982, 1985; Linn, 1982).

Some researchers emphasize that mathematics and science teaching should put a priority on developing logical thinking skills (Lawson, 1982; Garnett &Tobin, 1984), which is among the skills to be successful in these courses (Valanides, 1997). Moreover, Lawson (1982) asserts that logical thinking will increase the academic performance of the students not only in mathematics and science courses but also in other courses too. Similarly, Linn, Pulos and Gans (1981) state that logical thinking skills are necessary to overcome obstacles of daily life.

Above literature indicates that critical thinking and logical thinking are closely related concepts. Hence, the interrelationship of critical thinking and logical thinking is a cause of concern in a way that how is the logical thinking level of the students who have a high level of critical thinking or vice versa. To this end, the aim of the current study was to investigate the existence of the relationship between mathematics teacher candidates' critical thinking skills and their logical thinking dispositions. The research problem states: "Does there exist any relationship between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions?" There are three sub-problems as follows to address the questions:

1. Is there any relationship between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions in terms of their year (grade) in college?
2. Is there any relationship between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions in terms of high school type that they were graduated?
3. Is there any relationship between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions in terms of their gender?

METHODOLOGY

The current study utilized relational survey model that includes determination of the existence and/or the extent of the covariance between two or more variables (Gall et al. 1999; Gay, 1987, Karasar, 1991). In general, relational surveys aim to determine the distinctions between individuals, objects etc. rather than trying to measure their alignments with acknowledged standards (Karasar, 2003).

Sampling procedures

A total of 99 mathematics teacher candidates consisted of the sampling of the study. Participants were students in the department of elementary mathematics education at a university in Turkey. The percentage of the female participants was more than double of the one of the males (70 percent versus 29 percent, respectively). Fifty one percent of the participants were graduated from Anatolian high schools whereas 27 percent of them were graduated from regular high schools, and 21 percent from Anatolian Teacher high schools. The number of the teacher candidates who were in their second year in college (n=65) was more than the total number candidates who were in their third and fourth year in college.

Data collection tool

Two instruments were used to collect data in the current study. The first instrument was the Turkish version of the California critical thinking disposition inventory (CCTDI-R). The instrument was developed by Facione, Facione and Giancarlo. (1999) and was translated into Turkish by Kokdemir (2003). The translated version of CCTDI included 6 dimensions and 51 items. The dimensions and related reliability coefficient (Cronbach's alpha) of CCDTI are analyticity (0.75), open-mindedness (0.75), inquisitiveness (0.78), self-confidence (0.77), truth-seeking (0.61), and systematicity (0.63).

Being Likert-type six, CCDTI had the standard scores of 6 (minimum) or 60 (maximum) that were calculated though dividing the raw scores for each dimension by the number of the items and then multiplying it by ten. For CCDTI dimensions, Facione et al. (1998) accepted the scores below of 40 as low level of critical thinking disposition, the ones between 40 and 50 as medium level of critical thinking, and the ones over 50 as high. Therefore, for the whole CCDTI, the individuals who score less than 240 (40X6) can be regarded low in critical thinking dispositions and the ones who score more than 300 (50X6) can be regarded high in critical thinking dispositions (Kokdemir, 2003).

Second instrument was Turkish version of the group assessment of logical thinking (GALT). The instrument was developed by Roadrangka, Yeany and Padilla (1982) for measuring logical thinking abilities and translated into Turkish by Aksu, Berberoğlu and Paykoç (1990). The GALT instrument was composed of 21 items that were selected from the items of other instruments (Lawson, 1978; Longeol 1968). The reliability coefficient of Turkish version of the GALT instrument was calculated as 0.88 (Aksu et al., 1990). The GALT instrument included six sub-scales; conservational reasoning (4 items), proportional reasoning (6 items), controlling variables (4 items), combinational reasoning (3 items), probabilistic reasoning (2 items), and correlational reasoning (2 items). The instrument included 18 double multiple-choice items (items 1 through 18) and three constructed-response items (items 19-21). In responding the items 1 through 18, students were posed with a problem supported with pictorial presentation and asked to choose the best answer (from 2 to 5 possible answers available) for each stated problem. Then, students were required to choose the best justification for the chosen answer from a list of 2 to 5 possible justification. In scoring of the participants' scores on the GALT instrument, for the multiple-choice items, teacher candidates received 1 point for providing the correct answer with the correct reasoning behind it and 0 point when failed to detect any of them. For the constructed-response items, mathematics teacher candidates received 1 point for correct answers and 0 point for wrong answers.

Data analysis

Data collected through the instruments was analyzed by using SPSS 15.0. General characteristics of the research sample was determined by means of descriptive statistics and analyzed in order to answer the related research question. The relationship between logical thinking skills and critical thinking dispositions was analyzed by using Pearson correlation test. The effect size for each analysis was also reported. During all computations, p value was taken as 0.05.

RESULTS

The results regarding the teacher candidates' logical thinking skills and their critical thinking dispositions were provided in line with the research questions. In general, mathematics teacher candidates' critical thinking dispositions (X = 31.06) were lag behind the medium level based on the evaluation scale of Facione et al. (1998). Similar tendency were evident in the logical thinking level of teacher candidates, who had a mean of 10.82. When considered that the range of the points can be received in the LTSI is 0-21, it would not be a wrong assumption to assert that the participants of the study posses a low level of the logical thinking skill.

Figure 1 shows mean distribution of mathematics teacher candidates' logical thinking skills and their critical thinking dispositions based on their college grade level. According to Figure 1, mathematics teacher candidates' critical thinking dispositions had slight changes mu) across grade levels. On the contrary, teacher candidates' logical thinking skill scores indicated a leap between second (X=9.89) and third (12.77) grades. Moreover, second graders possessed the lowest mean score in logical thinking skills while they had the highest score for critical thinking dispositions.

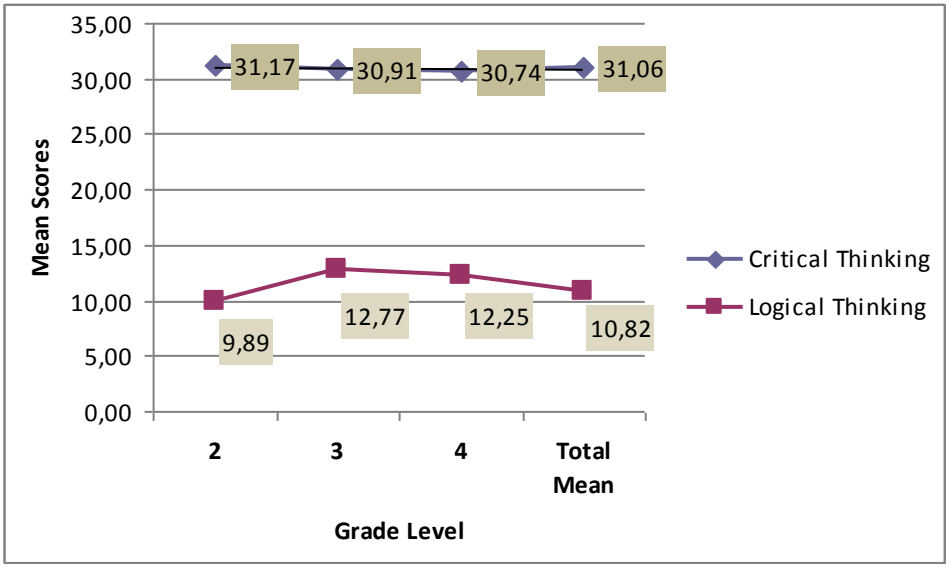

Figure 1. Mathematics teacher candidates' mean scores obtained from LTS and CCTD instruments based on their grade level in college

In Figure 2, the distribution of the logical thinking and critical thinking mean scores of mathematics teacher candidates based on their high school type was presented. It is evident from the figure that teacher candidates who were graduated from Anatolian high school had higher level of critical thinking than those who were graduated from the other high schools, while regular high school graduates possessed considerably low level of logical thinking skills among all high school graduates.

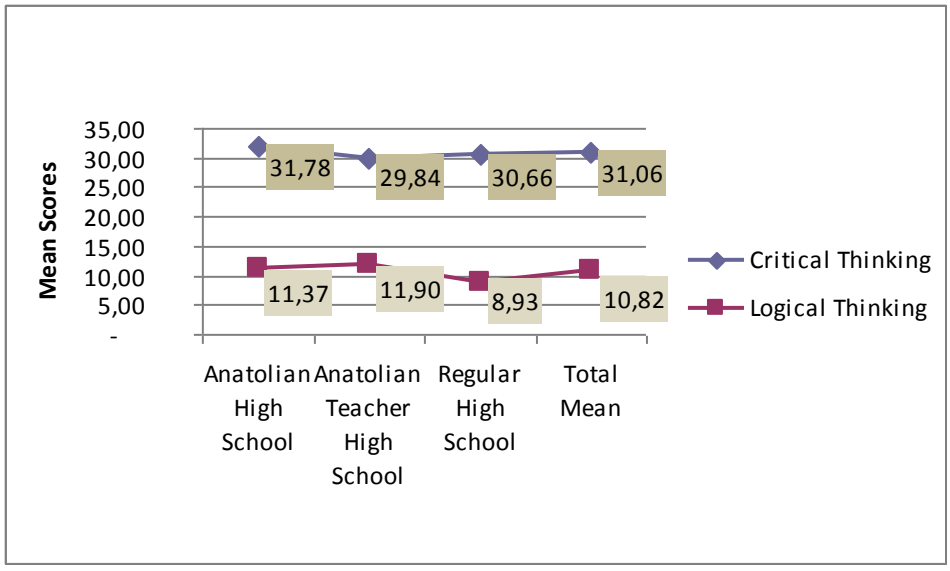

Figure 2. Mathematics teacher candidates' mean scores for the instruments in terms of their high school type

The distribution of the logical thinking and critical thinking mean scores of mathematics teacher candidates based on gender variable was presented in Figure 3. It can be deduced from the figure that critical thinking dispositions and logical thinking skills did not change considerably between male and female teacher candidates. However, the figure illustrated below shows slight differences in critical thinking dispositions in favor of females and in logical thinking skill in favor of males.

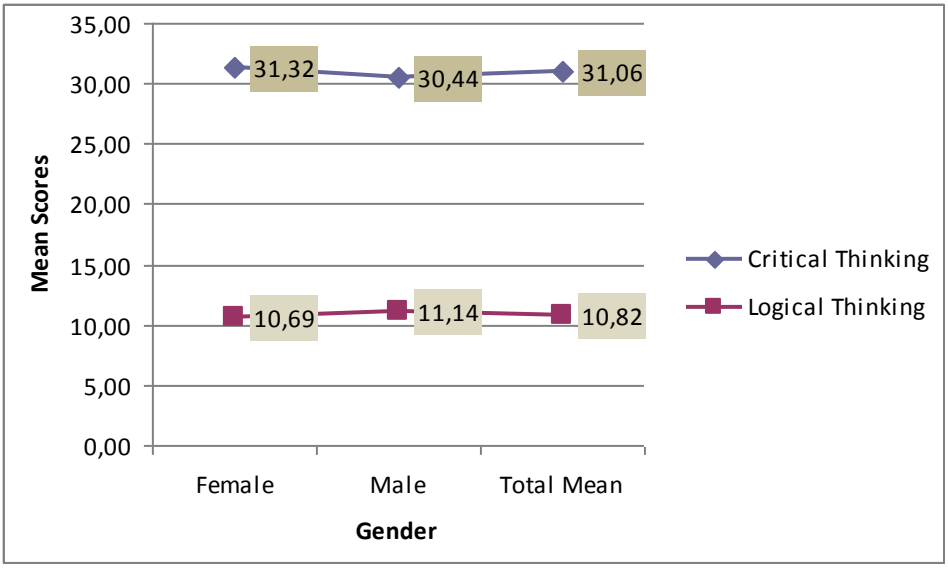

Figure 3. Mathematics teacher candidates' mean scores for the instruments in terms of gender variable

Table 1 shows the Pearson correlation test results between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions. According to Table 1, there exists a negatively directed weak relationship between teacher candidates' logical thinking skills and their critical thinking dispositions (r = -0.152; p = 0.133). Moreover, the dependency coefficient between logical thinking skills and their critical thinking dispositions was calculated as % 2.3 ($r^2 = 0.023$), which means that the variables are relatively independent from each other as seen in Figure 4.

Table 1. Pearson correlation test between mathematics teacher candidates' logical thinking skills and their critical thinking dispositions

		Critical thinking dispositions	Logical thinking skills
Critical thinking dispositions	Pearson Correlation	1	-0.152
	Sig. (2-tailed)		0.133
	N	99	99
Logical thinking skills	Pearson Correlation	-0.152	1
	Sig. (2-tailed)	0.133	
	N	99	99

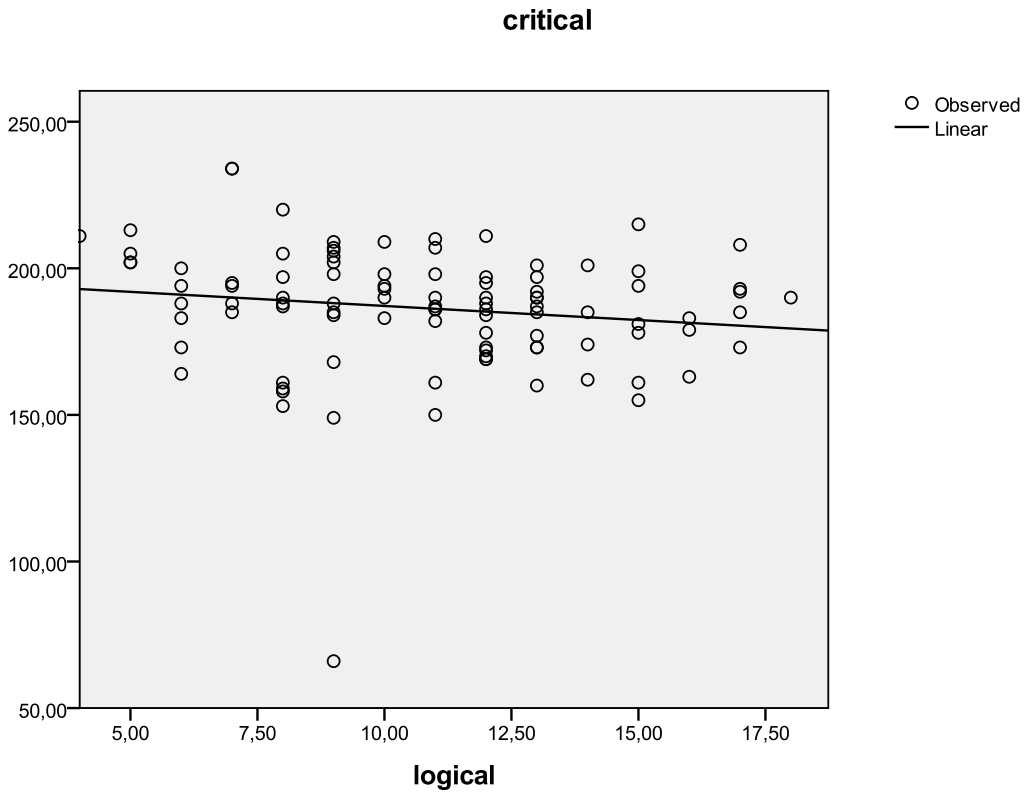

Figure 4. Relation between logical thinking skills and critical thinking dispositions

Results relating the first research question

Pearson correlation test was applied to mathematics teacher candidates' CCTDI scores and their logical thinking skills in terms of grade level in college (Table 2). The results indicated a weak and negatively directed relationship between mathematics teacher candidates' CCTDI scores and their logical thinking skills at all grade level (for the second graders r = -0.127 and p=0.313; for the third graders r = -0.096 and p = 0.670; for the fourth grade teacher candidates r = -0.421 and p=0.173).

Table 2. Pearson test results regarding the relationship between mathematics teacher candidates' critical thinking and logical thinking based on grade level

Grade Level			Critical thinking	Logical thinking
Second grade	Critical thinking	Pearson Correlation	1	-0.127
		Sig. (2-tailed)		0.313
		N	65	65
	Logical thinking	Pearson Correlation	-0.127	1
		Sig. (2-tailed)	0.313	
		N	65	65
Third Grade	Critical thinking	Pearson Correlation	1	-0.096
		Sig. (2-tailed)		0.670
		N	22	22

	Logical thinking	Pearson Correlation	-0.096	1
		Sig. (2-tailed)	0.670	
		N	22	22
Fourth Grade	Critical thinking	Pearson Correlation	1	-0.421
		Sig. (2-tailed)		0.173
		N	12	12
	Logical thinking	Pearson Correlation	-0.421	1
		Sig. (2-tailed)	0.173	
		N	12	12

Results relating the second research question

Table 3 shows the Pearson correlation test results relating mathematics teacher candidates' CCTDI scores and their logical thinking skills in terms of high school type. According to the table, a very weak and negatively directed relationship was evident between mathematics teacher candidates' CCTDI scores and their logical thinking skills based on their high school type that they were graduated from (for the Anatolian high school graduates r = -0.258 and p = 0.068; for Anatolian teacher high school graduates r = -0.084 and p = 0.719; for regular high school graduates r=-0.155 and p = 0.440).

Table 3. Pearson test results regarding the relationship between mathematics teacher candidates' critical thinking and logical thinking based on grade level

High school type			**Critical thinking**	**Logical thinking**
Anatolian high school	Critical thinking	Pearson Correlation	1	-0.258
		Sig. (2-tailed)		0.068
		N	51	51
	Logical thinking	Pearson Correlation	-0.258	1
		Sig. (2-tailed)	0.068	
		N	51	51
Anatolian teacher high school	Critical thinking	Pearson Correlation	1	-0.084
		Sig. (2-tailed)		0.719
		N	21	21
	Logical thinking	Pearson Correlation	-0.084	1
		Sig. (2-tailed)	0.719	
		N	21	21
Regular high school	Critical thinking	Pearson Correlation	1	-0.155
		Sig. (2-tailed)		0.440
		N	27	27
	Logical thinking	Pearson Correlation	-0.155	1
		Sig. (2-tailed)	0.440	
		N	27	27

Results relating the third research question

In Table 4, Pearson correlation test results relating mathematics teacher candidates' CCTDI scores and their logical thinking skills based on gender variable was provided. According to the table, a weak and negatively directed relationship was evident between female teacher candidates' CCTDI scores and their logical thinking skills (r = -0.222; p = 0.064). Similarly male mathematics teacher candidates' CCTDI scores and their logical thinking skills also had a weak relationship, but a positive relation was observed (r = 0.117; p = 0.545).

Table 4. Pearson test results regarding the relationship between mathematics teacher candidates' critical thinking and logical thinking based on gender variable

Gender			Critical thinking	Logical thinking
Female	Critical thinking	Pearson Correlation	1	-0.222
		Sig. (2-tailed)		0.064
		N	70	70
	Logical thinking	Pearson Correlation	-0.222	1
		Sig. (2-tailed)	0.064	
		N	70	70
Male	Critical thinking	Pearson Correlation	1	0.117
		Sig. (2-tailed)		0.545
		N	29	29
	Logical thinking	Pearson Correlation	0.117	1
		Sig. (2-tailed)	0.545	
		N	29	29

CONCLUSIONS AND DISCUSSIONS

This study aimed to investigate the existence of the relationship between mathematics teacher candidates' critical thinking skills and their logical thinking dispositions according to the variables of grade level, graduated high school type, and gender. The results obtained during this study were limited to the participants and the instruments that were utilized.

The current study indicated that mathematics teacher candidates had a low level of logical thinking. Similarly, participants' critical thinking dispositions also lagged behind the medium level. Similar results were also evident in the literature (Biber, Tuna, & İncikabi, 2013; Bulut et al., 2009; Dutoğlu & Tuncel, 2008; Şenlik, Balkan, & Aycan, 2011).

In terms of the college grade level, the current study also showed results that mathematics teacher candidates' logical thinking skills were improved from second grade to third grade level while their critical thinking skills did not change considerably. The improvement in the logical thinking skill from second grade to the later grades can be caused by the fact that mathematics teacher education programs in Turkey includes a majority of the content related and pedagogical courses during these years. Pedagogical courses, such as Methods of Teaching Mathematics and Instructional Principles and Methods, and content courses, such as Abstract Algebra, especially aim to improve teacher candidates' skills of logical thinking.

Another result of the current study was that mathematics teacher candidates' critical thinking abilities did not affect considerably by the high school type that were graduated from while regular high school graduates possessed lower level of logical thinking abilities than the others. This situation can be caused from the fact that students who receive high scored on Level Determination Examination, a national assessment for entrance to the secondary education institutions in Turkey, do not prefer to be placed in the regular high schools.

The current study also indicated that there was a weak and negatively directed correlation between mathematics teacher candidates' critical thinking dispositions and their logical thinking skills. Moreover, teacher candidates' grades in college, their high school type, and their gender did not provide any better relationship between teacher candidates' critical thinking dispositions and their logical thinking skills.

Based on the results obtained in this study, a general statement could be that there was no a considerable relationship between mathematics teacher candidates' skills of critical thinking and logical thinking. Moreover, teacher education program in Turkey could be taken as inefficient in improving their clients' skills of critical and logical thinking. Today's schools, it is expected from teaching strategies and adopted technologies to support

students' critical and logical thinking skills (Branch, 2000). Teachers have a key role during this process (Ennis, 1991). Halpern (1999) asserts that critical thinking skills could be taught, learnt, and defined, and students would be better thinkers when they learn and completely apply critical thinking. In the Turkish elementary school mathematics teaching program (MoNE, 2013), teachers were advised to apply different instruction methods to support and improve students' skills of critical thinking, logical thinking and problem solving. In order to satisfy this necessity, teacher education programs should aim to improve teacher candidates' these skills. Moreover, the assertion that critical thinking can be generalize helped to shape teaching programs, separate from the regular teaching subjects, that designed to teach critical thinking skills (Royalthy, 1995). Therefore, mathematics education programs should include specific courses or redesigned the existed ones to improve critical thinking skills.

AUTHOR INFORMATION

Lutfi Incikabi is assistant professor of Mathematics Education at Kastamonu University. He received an Ed.D. in Mathematics Education from Teachers College, Columbia University in 2011. He served at Mersin University as Teaching Assistant from 2011 to 2012. In 2012, he joined the faculty at Kastamonu University. Dr. Incikabı's research interests are elementary mathematics education, comparative education, teaching with technology. E-mail: lutfiincikabi@yahoo.com (Corresponding author)

Abdulkadir Tuna is assistant professor of Mathematics Education at Kastamonu University. He holds a Ph.D. in Mathematics Education. His research interests are elementary mathematics education and problem solving. E-mail: atuna@kastamonu.edu.tr

Abdullah Cagri Biber is assistant professor of Mathematics Education at Kastamonu University. He holds a Ph.D. in Mathematics Education. His research interests are elementary mathematics education, teacher education and problem solving. E-mail: atuna@kastamonu.edu.tr

REFERENCES

1. Akkuş, H. (2004). Kavramsal Değişim Metinlerinin Kimyasal Denge Başarısı Üzerine Etkisi. (Unpublished Doctoral Dissertation). Gazi University: Ankara.
2. Biber, A.C, Tuna, A. & İncikabi, L. (2013). An investigation of critical thinking dispositions of mathematics teacher candidates. *Educational Research, 4*(2), 109-117.
3. Branch, B.J. (2000). The relationship among critical thinking, clinical decision making, and clinical practica: A comparative study. (PhD Thesis). Universty of Idaho.
4. Bulut, S., Ertem G. & Sevil, Ü. (2009). Hemşirelik Öğrencilerinin Eleştirel Düşünme Düzeylerinin İncelenmesi. *Dokuz Eylül Üniversitesi Hemşirelik Yüksekokulu Elektronik Dergisi, 2*(2), 27-38.
5. Carr, K.S. (1988). How can we teach critical thinking? *Childhood Education, 65*(2), 69-73.
6. Demirel, Ö. (2003). *Planlamadan değerlendirmeye öğretme sanatı*. Ankara: Pegem A Yayıncılık.
7. Dutoğlu, G. & Tuncel, M. (2008). Aday Öğretmenlerin Eleştirel Düşünme Eğilimleri ile Duygusal Zeka Düzeyleri Arasındaki İlişki. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 8*(1), 11-32.
8. Ennis, C. (1991). Discrete thinking skills in two teachers' physical education classes. *The Elementary School Journal, 91*, 473–486.
9. Facione, P.A., Facione, N.C. & Giancarlo, C. A. F. (1999). *Professional judgment and the disposition toward critical thinking*. California Academic Press.
10. Gall, J., Gall, M.D., & Borg, W.R. (1999). *Appling educational research*. New York: Longman.
11. Garnett, P.J. & Tobin, K. (1984). Reasoning patterns of preservice elementary and middle school science teachers. *Science Education, 68*(5), 621-631.
12. Gay, L.R. (1987). *Educational research compentencies for analysis and application*. New York: Macmillan Publishing Company.
13. Halpern, D.F. (1993). Assessing the effectiveness of critik-thinking instruction. *The Journal of General Education, 42*(4), 338-353.
14. Halpern, D.F. (1999). Teaching for critical thinking: Helping college students develop the skills and dispositions of a critical thinker. *New Directions for Teaching and Learning, 80*, 69-74.
15. Karasar, N. (1991). *Bilimsel araştırma yöntemi*. Ankara: Sanem Matbaacılık.

16. Karasar, N. (2003). *Bilimsel Araştırma Yöntemi*. Ankara: Nobel Yayın Dağıtım.
17. Karplus, R. (1977). Science teaching and the development of reasoning. *Journal of Research in Science Teaching, 14*(2), 169-175.
18. Kazancı, O. (1989). *Eğitimde elestirel düsünme ve öğretimi*. İstanbul: Kazancı Kitap A. S.
19. Korkmaz, H. (2002). Fen eğitiminde proje tabanlı öğrenme yönteminin yaratıcı düşünme, problem çözme ve akademik risk alma düzeylerine etkisi. (Doctoral Dissertation). Hacettepe University, Ankara.
20. Kökdemir, D. (2003). Belirsizlik durumlarında karar verme ve problem çözme. (Unpublished Doctoral Dissertation). Ankara University, Ankara.
21. Külahçı, Ş. (1995). *Öğretmen yetiştirme modül serisi, D-mikro öğretim*. Ankara: Özışık Ofset Matbaacılık.
22. Lawson, A.E. (1982). Formal reasoning, achievement, and intelligence: An issue of importance. *Science Education, 66*(1), 77-83.
23. Linn, M.C., Pulos, S. & Gans, A. (1981). Correlates of formal reasoning: Content and problem effects. *Journal of Research in Science Teaching, 18* (5), 435-447.
24. MEB, (2012). *MEB, Öğretmen Yeterlikleri*. M.E.B. Öğretmen Yetiştirme ve Eğitimi Genel Müdürlüğü, Ankara: Milli Eğitim Basımevi.
25. Norris, S. P. & Ennis, R.H. (1989). *Evaluating critical thinking*. Pacific Grove, CA: Midwest Publications.
26. Özden, Y. (1997). *Öğrenme ve oğretme*. Ankara: Pegem Yayıncılık,.
27. Royalthy, J. (1995). The generalizability of critical thinking: Paranormal beliefs versus statistical reasoning, *The Journal of Genetic Psychology, 156*(4), 477- 488.
28. Selçuk, Z. (2001). *Gelişim ve öğrenme*. Nobel Yayın Dağıtım, Ankara.
29. Şenlik, N.Z., Balkan, Ö. & Aycan, Ş. (2011). Öğretmen adaylarının eleştirel düşünme becerileri: Muğla üniversitesi örneği. *Celal Bayar Üniversitesi Fen Bilimleri Dergisi 7*(1), 67-76.
30. Valanides, N. C. (1996). Formal reasoning and science teaching. *School Science and Mathematics, 96*(2), 99-111

